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The DORIC Program: Migration Issues

K. Fairs

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The DORIC Program: Migration Issues

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ABSTRACT

A number of requirements are emerging for the next generation of military communication networks. These include greater connectivity, improved interoperability and higher capacity, together with the enduring military requirement for security. This paper gives a high-level precis of significant areas that must be addressed in migrating from existing military networks to a goal architecture which will meet future military requirements. The challenges for a migration goal are not only technical but also organisational. The paper draws conclusions, and offers recommendations of future areas that would benefit from further research under the DORIC program.

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EXECUTIVE SUMMARY

This report has been written for the non-communications specialist. It identifies issues which will have to be addressed during formulation of a strategy to migrate from existing military communication networks to a highly interoperable corporate network, capable of transporting the volumes of information which will be required for effective military operations in the future.

A fundamental requirement for future Command and Control systems will be the ability to interoperate with other national and allied systems. The corner-stone of interoperability lies in compatible communications. Asynchronous Transfer Mode (ATM) is the switching and multiplexing technology which underlies Broadband-Integrated Services Digital Network (B-ISDN — the next standard for global civil communications. ATM has also been adopted by Information Technology (IT) industry as the next standard for local, metropolitan and wide area digital communications.

Current military Command and Control systems are based on the military message and voice communications systems. However, it is becoming evident that multi-media technologies, supported by broadband communications networks are becoming increasingly essential tools for effective military operations.

Before a migration strategy can be formulated, there must be a definitive and endorsed goal architecture. The two most significant knowledge gaps in this area are both the subject of active research at present under the Defence ORganisation Integrated Communications (DORIC) program. These are the security architecture and the tactical-level architectures. It is expected that this research will be completed by late 1995.

ATM is a broadband technology designed in the civil arena for transport over fibre optic cable. Fibre optic cable offers virtually unlimited bandwidth, is noise free and

has an extremely low error-rate. ATM has been optimised for this medium. Tactical military communications bearers such as satellite, tropospheric scatter and HF radio are noisy and may have to operate in an Electronic Counter Measures (ECM) environment. Hence there is a need to research how to bring the multiplexing and interoperability benefits of ATM to the tactical level. The ATM standard will require a military extension to optimise its survivability and efficiency if it is to be used at the tactical level.

Many of the economic benefits offered by ATM based networks can be justified only at the Portfolio level where the savings by bandwidth aggregation are greatest. However, this philosophy runs directly counter to Program Management Budgeting (PMB), which attempts to devolve business control to the lowest practical level.

The migration to the goal architecture is likely to be implemented by a process of evolutionary change as opposed to revolutionary change. Evolutionary Acquisition (EA) is a project acquisition method which is ideally suited to accommodate evolutionary migration.

Any goal architecture is going to be based largely on Commercial-Off-The-Shelf (COTS) products and civil infrastructure. While this commercially-driven solution has the advantages of cost effectiveness and interoperability, it does mean that timing of availability of elements of the system will be dictated by the commercial market place.

Fibre optic cable offers the potential of virtually unlimited bandwidth at modest cost. The fixed Australian Defence Force (ADF) assets which can be connected by fibre will present few technical or economic issues in migrating to a high capacity communications network. However, for the mobile military, the option with the greatest utility is satellite systems. Such technology is available but extremely expensive. Hence bandwidth provision at the tactical level is not technology-limited but budget-limited.

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1. Introduction

A fundamental requirement for future Command and Control systems will be the ability to interoperate with other national and allied systems. The corner-stone of interoperability lies in compatible communications. Asynchronous Transfer Mode (ATM) is the switching and multiplexing technology which underlies B-ISDN. Current technology forecasts are that B-ISDN will be adopted by the national telecommunications carriers for global communications before the end of this decade. Although ATM has its origins in the telecommunications industry, it has been adopted by Information Technology (IT) industry as the next standard for local, metropolitan and wide area digital communications. The US military is vigorously adopting ATM for its coming generation of communications networks. In addition for off-shore operations, Public Switched Telephone Networks (PSTNs) of cooperative nations are a potentially valuable source of communications bandwidth. To exploit this potential asset to the full, future military systems should be compatible with the evolving ATM standard.

The Defence Corporate Communications Plan (DCCP) Reference 1 has mandated maximum use of national civil infrastructure. The exact level of civil infrastructure to be used in a goal architecture is still a matter of conjecture. However, civil infrastructure will be based on Broadband Integrated Services Digital Network (B-ISDN) and therefore it is logical that future military architecture should be compatible with this standard.

Current military Command and Control systems are based on the military message and voice communications systems. Within the last decade, the facsimile machine has gained a prominent role in military operations. These systems are essentially narrowband technologies and, as such, only require support by narrowband communications networks.

The age of video teleconferencing is in its infancy. Although VIDCONNET, the strategic and operational-level video briefing system has been in existence for nearly a decade, its value for interactive exchanges has been exploited only recently. Future Command and Control systems may well be based on multi-media technologies. Multi-media technologies are inherently broadband and to function effectively require a broadband communications infrastructure. As well, the next generation of Defence sensors are expected to require broadband communications. For example, Unmanned Aerial Vehicles (UAV) equipped with real-time video systems, Synthetic Aperture Radar (SAR) and pre-filtered Jindalee Operational Radar Network (JORN) information.

The 1991 Gulf War re-inforced the requirement for Command, Control and Communications (C3) systems to be survivable. The Iraqi military machine was impaired significantly for the duration of the war when key C3 installations were destroyed by Coalition forces in the opening moments of the conflict. The solution lies in well-designed distributed systems and databases which avoid a single point of failure. To function efficiently and effectively such systems require interoperable broadband communications.

It has been estimated that the amount of information in the world is doubling every 3 years. In the military context this is perhaps a conservative estimate with the advent of new broadband sensors, and an increasing number and size of databases. The Gulf War was generally recognised as the first information war. The ability to manage, transport, and process the required volumes of information have become increasingly critical to military success.

For the foreseeable future there will be an enduring role for military signal and voice traffic. However, it is becoming evident that multi-media technologies, supported by broadband communications networks have become increasingly essential tools for effective military operations.

The ADF Command & Control Plan (ADFCCISP) published in July 1994, Reference 2, proposes the future direction for Australian C3 systems. The Plan addressed strategic, operational and tactical level C3 systems in service, in development and planned up to the year 2000. The Plan's opening quote is taken from an ex US Joint Chief of Staff, General Colin Powell:

> *"The ultimate goal is simple: give the battlefield commander access to all the information needed to win the war. Give it to him where he wants it, when he wants it and how he wants it".*

This relatively straight-forward and concise objective for a *C4I Super Highway* hid a multitude of technical, organisational and political challenges which will have to be addressed before communications to support such a goal is achieved.

2. Aim

This report identifies issues which will have to be addressed during formulation of a strategy to migrate from existing military communication networks to a highly interoperable high capacity corporate network.

3. Structure

This report is a level 2 document in current DORIC issue of reports and as such the content is kept to a high level with the style tailored for the non-communications specialist.

Defining the desired end-point, the goal architecture, is fundamental to any migration plan. In a section titled *Goal Architecture* a high level precis of related issues is given. In a section titled *Legacy Systems*, the role of these systems in the existing and about-to-be-implemented communications infrastructure is discussed. In order for any unexpected technological advances can be adopted in a timely manner, the importance of monitoring *Emerging Technologies* is then outlined. The possible impact of *Performance Management & Budgeting* (PMB) on migration planning is outlined. To gain project approval from higher Defence committees, projects have been required increasingly to justify themselves as business cases. Therefore, a section titled *Business-case Based Migration* addresses these issues. *Evolutionary Acquisition* is an evolving project acquisition technique which is complimentary to a major migration implementation plan. After *Migration Scheduling* issues are discussed, the report draws *Conclusions* about significant migration issues and offers *Recommendations* for future areas of DORIC research.

Definitions of narrow and broadband widths are a subjective matter. This report will follow the civilian protocol of calling bandwidth equal or less than 2.4 kb/s "narrowband", 2.4 kb/s up to 2 Mb/s "wideband" and greater than 2 Mb/s "broadband". Wideband data rates will adequately meet the requirement for basic multi media applications such as real-time high quality video conferencing and timely high resolution image transfer.

4. The Goal Architecture

Before a migration plan can be formulated, the most fundamental and demanding requirement is a clear and well-defined goal architecture. The following is a precis of key issues of any goal architecture.

4.1. Security Architecture

It is axiomatic that security of military operational and intelligence information will always be essential. Hence a fundamental element of a military communications network will be its security architecture. Goal communications architecture will remain incomplete until a goal security architecture is proposed and endorsed.

Security issues are an area of intense research activity under the DORIC D6 study and are given a fuller coverage in two concurrent reports, References 3. & 4 However this report will identify high level issues.

4.1.1.Traffic Flow Security

Based on an economic considerations, the DCCP has mandated greater use of the civil networks. For reasons of cost effective bandwidth management, these networks are based on switched technologies. If such networks are to be used to carry military classified traffic, the information content will have to be encrypted to prevent unauthorised eavesdropping or modification. However, for the public network to carry out the appropriate switching, the address information located in the header of any cell, packet or frame will have to be clear. This configuration will leave Defence traffic open to traffic analysis which is a rich source of intelligence to any would-be enemy. Full Traffic Flow Security (TFS) will be possible only by the extensive use of dummy traffic. However employing dummy traffic runs directly counter to many of the economic advantages of using civil carriers.

There are many partial implementations of TFS which may present a more economic solution, but detailed policy guidance will be needed as to the granularity of security protection required. This guidance will be required before any security architecture, hence goal communication architecture, will be complete.

4.1.2.Retrofittable Security Devices

From an academic viewpoint, security must be designed into a system and cannot be retrofitted. Current implementations of systems designed with a very high degree of security are prohibitively expensive and tend to give the end-user very restricted functionality. Hence retrofittable security devices have been developed. Examples of such devices are *Speakeasy*, a secure phone/data transfer device which uses the Public Switch Telephone Network (PSTN), and *STUBS*, a family of equipment which ensures a tamper-proof audit trail is made of information flowing from a higher classified network to a lower classified network.

From a migration perspective, retrofittable security devices offer a valuable option. Core systems can be implemented taking advantage of advanced technologies and initially operated at system high. This means a cost penalty in terms of clearances of personnel and secure premises. As and when suitable retrofittable devices become available, the system can be expanded to meet its full user requirement. However, this strategy reflects the reality of the current situation and runs counter to the structured approach of defining the security architecture up front.

4.2.Bearer Architecture

It has been postulated by many communication visionaries that the advent of fibre optic cables will lead shortly to unlimited bandwidths at negligible cost. While this is an exaggeration — as the labour costs to operate and maintain fibres are high — it is unquestionably true that bandwidth capacities to fixed installations connected by fibres will present few technical problems. However, communications problems for the mobile military will be enduring ones.

Broadband mobile communications can be dealt with at 2 levels: within the Australian Mainland; and offshore.

4.2.1.Within the Australian Mainland

Australia is fortunate to have an extensive network of civil communications infrastructure based largely on fibre optics. If the area of military operations is within Line of Sight (LOS) of a node of this bandwidth-rich network, broadband radio LOS technologies could be employed to extend the civil broadband networks. If the Area of Operations is beyond LOS, then options include:

4.2.2.Tropospheric scatter.

This is an established military and civil communications mode but previous implementations have required high-powered transmissions and large fixed installation high-gain aerials. Advances in digital signal processing and Radio Frequency (RF) technologies have now brought available transportable systems to within realistic costs. These can support broadband communications up to ranges of 500Km.

4.2.3.Re-transmissions by land, air or space based repeaters

Setting up and maintenance of, possibly a chain of LOS land-based repeaters, in remote and possibly hostile locations is a significant military operation. Airborne repeaters can offer coverages of 500Km, depending on height of operation, and can be located on specialised aircraft or Unmanned Aerial Vehicles (UAV). However, these too are a significant logistic enterprise and would present a high-value target to the enemy. Space-based systems can support global coverage broadband communications but carry a high price tag. The cost of installing and operating such a network is certainly beyond the grasp of the Australian Defence Force budget which would limit such a service to a small number of essential uses.

4.2.4.Off-shore

If off-shore operations are conducted in a co-operative country, use of the host country's civil network may be an option. If necessary, the civil network again can be extended by tropospheric scatter equipment. If the country is non co-operative, satellite technology offers the greatest utility and flexibility to support broadband communications.

Ideally any communications satellite would be wholly defence-owned. Politics permitting, other options would include loan of transponder space from a multi-national partner, lease of civil transponder space, or use of civil switched segments. The last option is the least preferable since access would be by contention and hence could not be guaranteed in time of need.

4.2.5.Enduring Requirement for HF

Budget constraints will mean that the ADF is unlikely ever to have all the bandwidth it desires. At the mobile tactical level for the ADF, High Frequency (HF) radio will have an enduring role for the foreseeable future. HF radio is a cost-effective bearer and can offer global coverage. However, its disadvantages are restricted availability caused by perturbations of the ionosphere and its inherent limitation as a narrowband medium. The typical data rate for current HF modems is 2.4Kb/s, with 4.8Kb/s modems also becoming commercially available, e.g. the DSTO Marconi modem currently available as a demonstrator prototype. As more processing power becomes more cost-effective and available, it is postulated that 14.4Kb/s HF modems may be developed in the medium term. Even these data rates are well short of the requirements for full multi-media applications or to transport the future volume of mission-critical Command and Control information.

4.2.6.Tactical Bearer Bit Error Rate

Tactical military communications bearers such as satellite, tropospheric scatter and HF radio are inherently noisy. In addition, tactical bearers may have to operate in an Electronic Counter Measures (ECM) environment. Therefore, such bearers have very high bit error rates (BER) when compared to fibre cable.

4.3.Bandwidth Considerations

As bandwidth at the tactical level for the ADF is going to be a limited and precious resource for the foreseeable future, intelligent gateways will be needed. These gateways will be required to police the interface between the broadband strategic/operational networks and the narrowband tactical level communications, in US parlance referred to *Unrestricted* and *Restricted* networks respectively. By way of example, the ADF is likely to have only Parakeet operating at a maximum wideband

communications (512Kb/s to brigade level) and single channel HF (probably 4.8 Kb/s to front line) — creating a potential information bottleneck.

Storage and processing devices for digital data are cheap and robust. Such hardware, with intelligent preparations for battle, could minimise communications traffic required at the tactical level. One example of such an arrangement, from an Army perspective, could be that major information downloads from an operational HQ, such as battle maps and the latest enemy intelligence images, could be despatched infrequently by courier on re-writable CDROM. The communications system would then be required only for high priority updates. Such a system could also work in reverse for information can be passed from the tactical level back to the operational HQ. In addition, all processing can be done locally, further reducing the burden on communications.

4.4.DORIC Goal Architecture Research

The *Defence Fixed Networks Migration Study,* Reference 5 published December 1993, addressed the fixed strategic and operational level communications networks. It identified options for migrating these currently narrowband to support broadband communications. However, it can be argued that this work is incomplete as an endorsed security architecture is still required. Such an architecture is expected as the primary output of the DORIC D6 study due late 1995.

Some work has been completed on tactical trunk communications. No research has been done, however, on tactical-level communications.

4.5.Commercial Support Program

In 1990 Wrigley published a report titled *The Defence Force and the Community* which identified considerable ($350 million) scope for industry support to the ADF in the areas of contracting and commercialisation. The 1991 Force Structure Review stated that contracting out support functions would release resources and funding to enhance the combat potential of the ADF. From these two reports the Commercial Support Program (CSP) was born.

Under the auspices of CSP, there will be pressure for future military communications networks, to be operated and maintained by civil personnel to the limits of acceptable availability and security considerations.

4.6.Commercial-Off-The-Shelf Technology

In the 1960s and 70s, military R&D led the commercial sector in most fields of technology. However, the situation has now changed radically. First, the complexity of

modern systems means there are extreme development costs. Second, with economies of scale in the commercial market place, very complex systems can be produced and sold for relatively low unit cost. Hence there is a growing acceptance that the military should take maximum advantage of Commercial-Off-The-Shelf (COTS) products where possible. The principal advantage of using COTS products is high functionality at modest cost. Military communications systems can unquestionably make extensive use of COTS because the military requirements for products are similar to commercial ones.

However, there are negatives to using COTS products. Key problems are the lack of visibility of source code (hence difficulty of interfacing, maintaining and certifying the trustworthiness of systems); keeping pace with software revisions; and the higher stress demands placed on systems by military than by commercial users. An indirect problem also arises if the military is dependent on COTS – future military systems will be shaped by what the commercial sector develops and makes available.

4.7.Use of civil infrastructure

Fortunately, Australia is a world leader in the quantity and quality of its civil communications infrastructure. For example, over 1.5 million kms of modern fibre optic cable has been laid across the continent. As well, a single standard mobile telephone network covers 90% of the country's population. There are many reasons for this rich infrastructure: the geographical sparseness of the population and the willingness of Australian society to embrace new technologies; as well, until recently there has been one major carrier, Telecom. All these have combined to give Australia over $26 billion worth of installed civil communications infrastructure.

The DCCP has mandated the ADF should make maximum use of this civil infrastructure. While the economic case for this directive is overwhelming, there will always be caveats, the prominent being security and survivability. In order to assist defence network planners on when it is (and when it is not) appropriate to employ civil assets, DSTO has developed a risk analysis methodology which can be applied to civil communications systems.

4.8.Standards

Modern joint warfare concepts mandate the need for an integrated command of Navy, Army and Air Force assets. In time of conflict, the ADF will have to work closely with many Other Government Organisations (OGO) and allies. Interoperability will be a key issue in enabling such diverse organisations to collaborate effectively. The corner-stone of achieving interoperability will be standards.

There are two major challenges for communications standards. First, the increasing rate of technological advances and the delays for the necessary processes to be approved have meant that standards are transient and normally lag behind state-of-

the-art technologies. Second, open system standards generally support extremely rich functionality. Therefore, system implementations therefore require tailoring of such standards to meet an organisation's unique business needs. Unless this tailoring is co-ordinated centrally, ideally at the highest level, the functions offered by the overall system can degenerate to the lowest common denominator of the interconnected systems.

4.9.Emergency Essential Network

The military requirement is likely to remain for a wholly-owned Defence network which can be used during local or wide spread disruption to the civil communications network. Such a Defence network will be needed to ensure a minimum level of highly secure data transmissions between military commanders. The current network is known as Minimum Essential Emergency Network (MEEN). Future similar networks are likely to be based on HF, and will support only narrowband communications — a key limitation.

The goal architecture should integrate with this essential emergency network and must ensure that it can deliver the required quantity of vital traffic in time of need.

5. Legacy Systems

Defence has already invested extensively in communications infrastructure. All of this infrastructure is essentially narrowband and incapable of supporting the emerging user requirement for broadband communications. However, some of this infrastructure can be expected to have fielded hardware in over 20 years time. Examples of such projects, DISCON and JP2043, are outlined below.

The challenge for a communications migration plan is how to integrate these legacy systems until the end of their economic life.

5.1.DISCON

The Defence Integrated Secure Communications Network (DISCON) has been accepted into full service only recently. It is a Wide Area Network (WAN) with extensions to all major establishments in the Australian Defence Organisation (ADO). Its bearers include leased Telecom and Optus lines, Defence-owned microwave links (DLOS), satellite (through leasing a portion of a transponder on an Optus AUSSAT B series satellite) and HF radio. The system offers full traffic flow security and encrypts the information content with military-grade cryptographic equipment.

5.2.JP2043

JP2043 is a tri-service project which aims to provide the ADF with a wholly Defence owned HF Wide Area Network (WAN). The project is currently in the project definition stage of procurement and is due to enter service in 1999. The system is designed to carry voice, messaging and facsimile at data speeds of 2.4Kb/s. However, it is anticipated that the project acquisition strategy will have provision to take advantage of new technologies as they become available.

6. Emerging Technologies

The rate of technological change is ever-faster and makes technology-forecasting increasingly problematical. Communications and computer products are often obsolete within 3 years of entering service. One recent example of this was Telecom Australia's decommissioning of a 4-year-old telephone exchange in Brisbane as it was beyond its economic life. The trend is likely to continue.

The challenge for any migration plan is how best to prepare to embrace technological advances. No migration plan can ever be 100% future-proof. Therefore, emerging technologies and mechanisms for early timely implementation of any significant and unforeseen technology leaps.

Two examples of where the full impact of emerging technologies is not yet known but may hold significant benefit for the ADO are given below.

6.1.LEOSATS

The current generation of communication satellites are based generally on large, expensive geostationary spacecraft. Satellites in geostationary orbit, that is 36,000 kms above the earth, maintain a fixed position relative to the earth's surface. Their footprint can cover approximately 40% of the earth's surface. However, this large distance means high-powered transmission and/or high aerial gains. The next generation of communication satellites, due to enter commercial service in 1997, is based on Low Earth Orbit (LEO) Satellite technology. Such satellites are very small (perhaps as small as 30 cm cube), light in weight, are designed for short lives, and orbit approximately 1,000 kms above the earth's surface. This relatively short distance means much smaller transmission powers and/or aerial gains are required. However, there are penalties with such systems. These satellites have foot prints which cover a small fraction of the earth's surface, so that a constellation of satellites is required for global coverage. The US Iridium system is planned with 66 satellites to provide global coverage.

By designing such satellites with relatively simple onboard communication systems and limited redundancies and maintaining the satellites by replacement, LEOSATS can be manufactured cheaply. Additionally their shorter operational lifetimes means

complex station-keeping systems can be avoided so reducing further the complexity, bulk and cost of the spacecraft. Such satellites are physically small and light-weight and require projection into low earth orbit only: this means that multiple satellites, perhaps 20 at a time, can be placed in orbit from a single conventional launch vehicle. Launch costs, therefore, are comparatively low.

The ADO is fortunate in that its Area of Direct Military Interest (ADMI) is centred approximately on the equator. This means that a small number of LEOSATs, perhaps only 6 in equatorial orbit, can provide continuous coverage.

6.2.Wireless LANs

Local Area Network cabling in commercial buildings is an expensive component of computer installations, and large organisations are often changing and reorganising. In general, it has been found that the location of LAN cabling over 3 years old has been documented so poorly, and cabling standards have risen so markedly that it is more cost-effective to re-wire entire buildings to meet the requirements of reorganisations. Wireless LAN technology has been developed to meet this market need. The principle is to locate a fixed transmitter receiver centrally, say on each floor of a building, and equip each computing device with a similar wireless LAN device. Staff can relocate computing devices in an office space without concern for fixed LAN wiring. Similarly, correctly equipped laptop computers can roam around the building while maintaining full connectively to the corporate network.

Wireless LAN technology comes in two flavours, low-powered spread spectrum microwave and Infra Red (IR). Ethernet bandwidths can be supported, that is 10 Mb/s. This technology could be extended to provide broadband communications to the military tactical environment in a cost-effective way.

7. Program Management & Budgeting

The foundation for the Program Management and Budgeting (PMB) was layed in April 1984 when the Government published its *Budget Reform* policy paper. The paper introduced two complementary reforms, namely the Financial Management Improvement Plan (FMIP) which aimed to streamline the budget process, and the PMB designed to set objectives and measure performance against these objectives. Under PMB funds were no longer allocated by a system of votes (for specific kinds of spending) but by program managers and their subordinate managers. The principal intentions of PMB were to bring a more commercial-orientated approach to defence procurement and to increase the job satisfaction of defence managers by devolving

management of funds to the lowest practical level within the organisation. PMB was introduced formally into the ADO on 1 July 1990.

Under PMB, each Program, and possibly Sub-Program, could be responsible for its entire business management. Conceivably each individual Program could be responsible for its communications. Ignoring the economic penalty this would lead to (discussed later), there is the potential for uncoordinated migration strategies to lead to a significant loss of interoperability particularly during the transitional period.

8. Business-Case Based Migration

There is increasing pressure for all military projects coming before higher Defence committees for approval to justify themselves as business cases. Two broad categories of issues need to be addressed: Costs and Benefits.

The cost side of the equation is relatively straight-forward as it involves tangibles. However, the benefits side of the equation, which calls for radically new ways of doing business is a highly subjective issue to quantify. For example, what dollar cost do you place on interoperability or winning a battle? Over the years a number of techniques have assisted with this problem, e.g. Measures of Effectiveness, Measures of Performance, and Measures of Merit. However, none has gained universal acceptance indicating the intractable nature of the problem.

Defence Material Division is currently introducing the ACE (Assessment for Cost-Effectiveness) for C3I, a structured method for quantifying the cost-effectiveness of future projects. The aim of the method is to match options for future systems and opportunities to achieve Defence's strategic priorities as defined in STRATCONCEPT (Strategic Concepts) documents.

8.1.Costs

These must include through-life costs, that is, beyond the capital acquisition costs, the costs of transitional arrangements and whole-life support costs. As well, the technical risks associated with the project, and the impact of any technical failures or delays in the procurement plan must be estimated. Where the project will mean a revised way of doing business for the organisation, the cost of business re-engineering, i.e. revision to doctrine must be estimated.

8.2.Benefits

The dollar benefits of cost-effective bandwidth allocation and control are relatively easy to define. Such benefits also arise from the impact of any new operational capabilities, e.g. multi-media, desk-top video conferencing, high-resolution image

transfer and collaborative working. The benefits of enhanced interoperability with potential allies and civil infrastructure should be quantified.

Many of the economic benefits offered by ATM-based networks can be justified only at the higher levels of the ADO where potential savings by bandwidth aggregation are greatest. Individual programs in themselves may be unable to raise sufficiently strong business cases for migration.

9. Evolutionary Acquisition

The Defence approval process is based on the classical Waterfall (so called because of the serial nature of activities) procurement strategy. This is a mature project management technique which has been taught for over 20 years and occupies a salient position within higher Defence committees. Traditionally, organisations have considered it a safe, logical, systematic approach to project management. The classical technique is based on analysing the market need, specifying the requirement, evaluating design options, and implementing and supporting the favoured option. However, there are three problems with this technique. It assumes:

- A specification for the total requirement can be wriitten at the beginning of the project cycle;
- The requirement remains stable during the implementation; and
- The system can be modelled using structured analysis techniques.

However, for C3 systems it is now acknowledged that it is impossible to specify all the user requirements up front. Many requirements for C3 systems can be derived only from the experience of actually using the systems. Technology is also advancing at an ever-increasing speed. Hence, more advanced products are becoming available which can enable C3 tasks to be completed more efficiently and effectively. Moreover, the threat is continually evolving. As a consequence, for C3 systems a change in requirements will be the rule rather than the exception. A further key fact is that C3 systems have an intrinsic structural complexity that makes structured analysis techniques inappropriate. Therefore, there is growing acknowledgment that procurement strategies based on the Waterfall methodology are inappropriate for C3 Systems. Experience demonstrates that such methods are in part responsible for projects being over-budget, behind schedule and obsolete on installation. As a consequence, the delivered systems have often generated much user-dissatisfaction.

An alternative approach is the new and emerging procurement strategy called Evolutionary Acquisition (EA) in which systems are developed incrementally. In EA, a core or baseline capability and subsequent increments are procured as distinct projects for which risk can be kept to an acceptable level. Therefore, a correctly-managed EA

can reduce significantly a project's exposure to cost, schedule and technical risks. The main advantage of EA is that it provides a method to adapt systems to changing user-requirements in a cost-effective and timely manner. Initial experience from the US military and civilian environments has validated the underlying principles of the concept.

EA conflicts with the current Defence approval processes on many counts. The main problem lies in that all-up project costs cannot be identified at the time of project initiation. The timing for traditional approvals is based on the annual national budget cycles, the governing regulations of which are enshrined in the Constitution and Common Law. EA increments require approvals much more frequently. Consequently, if full EA projects are to be implemented by the ADO, significant changes in the Defence procurement process will be required.

10. Migration Scheduling

10.1.Uer Requirement Pull/Technology Push

Timing of any advanced technology project is a critical element in its success. A key influence in a migration strategy from current existing systems to fully interoperable high-capacity communication networks will be achieving the balance between user-requirement pull and technology push. Many Command and Control requirements are deduced from the operational experiences of using the system in real situations. Hence, the full user-requirement is not likely to be known until the system is fielded.

10.2.Transitional Arrangements

The scope, complexity and cost of any project to migrate from current systems to fully interoperable high capacity networks dictate that the transition will almost certainly be incremental in nature. Hence a number of transitional arrangements will be necessary during the migration. An examples would be intelligent gateways to interconnect the new network to the existing communications infrastructure. Such transitional arrangements will have a cost penalty and could lead to a loss of interoperability during the migration phase.

Transitional arrangements can give rise to hidden costs. For example, with LAN interconnection, TCP/IP has grown in acceptance and is likely to be a significant protocol in LAN interconnects for many years. Hence, it is certain that there will be a requirement to pass TCP/IP over ATM until ATM on the desk top is implemented universally. This type of transitional arrangement does not make optimum use of available bandwidth and therefore is a hidden cost for the period of migration.

10.3.Commercial Availability

Any goal architecture will almost certainly be based largely on COTS products and civil infrastructure. While this commercially-driven solution has the advantages of cost effectiveness and interoperability, its does mean the commercial market place will determine the timing and availability of the system's elements.

11. Conclusions

The current Defence communications infrastructure is based on narrowband technologies which have been implemented with discrete systems based on propriety standards. Future Command and Control applications are likely to be multi-media based, distributed in topology, and will have a fundamental requirement for greater interoperability. The next generation of Defence sensors is likely to require broadband communications. Hence there are a large number of communication demands on the horizon which cannot be met by the existing infrastructure. If Defence is to maintain its technological capability and knowledge-edge, it will require a high-capacity secure communications network which will seamlessly span all dimensions of the ADO.

ATM, as the information transport mechanism to underpin such an interoperable high capacity network, is an inevitable choice. It has the following attributes: its ability to aggregate (and hence manage cost-effectively) all current and foreseen Defence traffic in a single network; its seamless integration to civil infrastructure; its full useof COTS products; and its interoperability with OGOs and Australia's major allies.

ATM is a broadband technology designed in the civil arena for transport of information over fibre optic cable. Fibre optic cable offers virtually unlimited bandwidth, is noise free and has an extremely low error-rate. ATM has been optimised for this medium. Tactical military communications bearers such as satellite, tropospheric scatter and HF radio are noisy and may have to operate in an ECM environment. In consequence, such bearers have relatively high bit error-rates when compared to fibre optic cables. Hence there is a need to research how to bring the multiplexing and interoperability benefits of ATM to the tactical level. The ATM standard will require a military extension to optimise its survivability and efficiency if it is to be used at the tactical level.

Before a migration strategy can be formulated, there must be a definitive and endorsed goal architecture. The two most significant knowledge gaps in this area are both currently being researched actively under the DORIC program. These are the security architecture and the tactical-level architecture. It is expected that these gaps will not be resolved until late 1995.

Many of the economic benefits offered by ATM-based networks can be justified only at the Portfolio level where the savings by bandwidth aggregation are greatest. However, this philosophy runs directly counter to PMB, which attempts to devolve business control to the lowest practical level. However, there are strong business and technical reasons why the migration should be implemented on a corporate basis. Modification of the ADO's implementation of PMB in relation to communications may be appropriate in the future.

Any migration from existing communications networks to a fully interoperable high capacity network can be expected to be implemented by a process of evolutionary change as opposed to revolutionary change. Evolutionary Acquisition is a project acquisition method which is ideally suited to accommodate evolutionary migration. However, much more work should be done to promote its advantages and hence acceptance by the higher Defence committees.

It is almost certain that any goal architecture is going to be based largely on COTS products and civil infrastructure. While this commercially-driven solution has the advantages of cost effectiveness and interoperability, it does mean that system availability may be dictated by the commercial market place.

No migration plan could ever be 100% future-proof. Therefore, there should be provision for monitoring emerging technologies and mechanisms for early implementation of any significant and unforeseen technological leaps which can be beneficially adopted by the ADO.

Absolute TFS will be expensive to implement and runs counter to the economic rationale for using any public switched network. There are many partial implementations of TFS which may present a more economic solution, but detailed policy guidance will be needed as to the granularity of security protection required. This guidance will be required before any security architecture, hence goal communication architecture, can be completed.

Fibre optic cable offers the potential of virtually unlimited bandwidth at modest cost. Fixed ADF assets which can be connected by fibre will present few technical or economic issues in migrating to a broadband communications network. However, for the mobile military, the option with the greatest utility is satellite systems. Such technology is available but extremely expensive. Bandwidth provision at the tactical level is not technology-limited but budget-limited.

12. Recommendations

The two most significant knowledge gaps in formulating the DORIC goal architecture are:

(a) The security architecture; and

(b) A tactical level architecture.

The security architecture is currently being researched under the DORIC D6 program and initial studies into a tactical-level architecture are being conducted.

ATM is a light-weight protocol-optimised for fibre transmission. There is a need to research how to bring the benefits of ATM to the tactical level in the most bandwidth efficient manner. Much work has been done on this topic overseas, principally by France and US. Research is required to determine which is the most applicable option for the Australian environment. This issue is increasingly moving onto the critical path for defining the goal architecture.

It is almost certain that any goal architecture will be based largely on COTS products supported by ATM-based communications. Both of these areas are covered by evolving internationally-agreed standards. DORIC studies should support work in formulating these standards to try to ensure that the military requirement is reflected in emerging standards. Strategic alliances and personnel exchanges with key manufacturers may also be an option.

To ensure that a goal architecture is able to take advantage of technology developments, effort should be directed to technology forecasting, monitoring of COTS developments, and early feasibility studies of promising products. Examples of such technology areas currently are wireless LAN systems and LEOSATS.

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Ken Fairs

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19. Abstract

A number of requirements are emerging for the next generation communication networks. These include greater connectivity, improved interoperability and higher capacity, together with the enduring military requirement for security. This paper gives a high-level precis of significant areas that must be addressed in migrating from existing military networks to a goal architecture which will meet future military requirements. The challenges for a migration goal are not only technical but also organisational. The paper draws conclusions, and offers recommendations of future areas that would benefit from further research under the DORIC program.